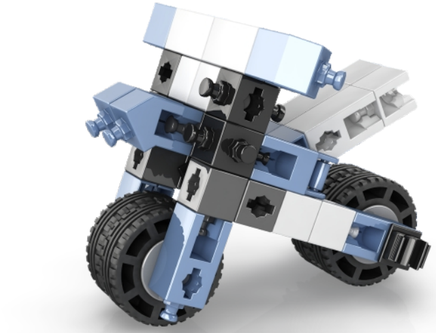
Experiment with the motordrome

As you have already learned a motorcycle is a wheeled motor vehicle used for multiple purposes like for transportation, for sports and for many other occasions. Different extreme sports with motorcycles demand high speeds in a curvy or circular paths. There is a specific speed limit a motorcycle should have in order to stay in its circular orbit. This limit depends on different elements such us the corner apex, the motorcycle wheels and the road surface. Motorcyclists should be careful not to exceed this limit since it may cause a motorcycle derailment and motorcyclist fatal injuries too.



- Which factors affect the derailment of a motorcycle?
- Will a lightweight motorcycle derail less or more?

Are you ready to discover how high speeds assist a motorcycle to achieve a circular motion?
Let's perform the next page's experiment to find out the answers for all these questions!
Get ready to discover what centrifugal force is and which factors affect it.

01

Learning about: **Centrifugal Force**

Motordrome

Motordrome is an extreme sport. Motorcyclists ride around the inside of a vertical wall, rather like a huge cylinder barrel, at high speeds. Perform the experiment below to observe this happening.

Discover:
- What is centrifugal force?
- Which factors affect the centrifugal force?

Level Of Difficulty ★★★☆☆

Materials Needed:
- Engino® (STH22).
- A4 paper, scissors, stapler or glue.
- String (about 50cm long)

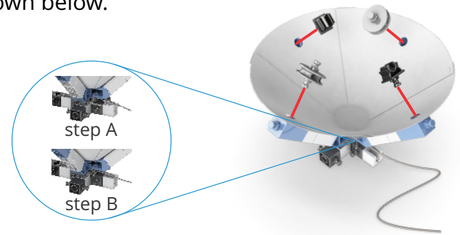
Procedure:

1. Find the instructions and build the **Motordrome** model.

2. **Print** the last page and follow the instructions to create a conical cavity. Then do **exercise 1**.

3. Place **mass A** in the conical platform. Hold the model from the edge of its base and use your finger to apply a force in order to rotate the conical platform. Do **exercise 2**.

1. a) Place the conical cavity onto the model, **b)** use your pen to make four holes on the paper and **c)** tie the one end of the string around the pulley as it is shown below.



2. Is Mass A spinning around the conical platform or does it stay still on the base of it? Why is this happening?

Mass A

Mass A stays still on the base of the platform. This is happening because the force, and therefore the speed, are not enough to make it move in a circular motion.

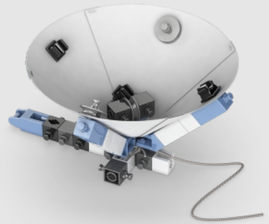
02

Procedure:

4. Note that **mass A** should be placed in the conical platform for every trial. For **cases 1**, **2** and **3** turn the string around the pulley **1, 2** and **3 times** respectively by holding the other end of the string stretched. For each case hold the model from the edge of its base and pull the string. Do **exercise 3**.

5. Place **mass B** in the conical platform together with **mass A**. Turn the string around the pulley **3 times**. Hold the model from the edge of its base and pull the string. Repeat the same **3 times** and observe which mass escapes first. Then, complete **exercises 4** and **5**.

Mass B



3. a) In which case does mass A escape from the platform? Which factor do you change when rotating the string more times around the pulley?

b) Why do you think the mass escapes from the conical platform?

a) In case 3 the mass escapes from the platform. By rotating the string more times around the pulley we increase the speed of the platform.

b) The mass escapes from the platform because it gained much speed.

4. Put a tick ✓ in the appropriate cell of the table regarding which mass escaped first.

	Mass A	Mass B
1st trial	✓	
2nd trial	✓	
3rd trial	✓	

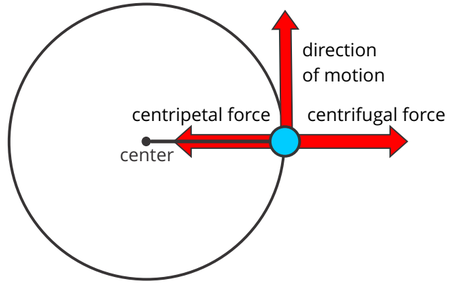
5. Which mass escapes first? Why do you think this is happening?

Mass A escapes first. This is happening because it has less mass and it gains more velocity.

Theory

Circular Motion

Circular motion is defined as the rotation about a point following a circular orbit. Whatever the object is, if it moves in a circular path, there is some force acting on it causing it to change from its straight-line path, accelerate inwards and move along a circular path. The 2nd law of Newton is introducing the 3 key concepts, Force, Mass and Acceleration, which describe the motion of objects. For circular motion, we will introduce equivalent terms which are specifically used for such cases. An example of circular motion is a race motorcycle turning through a curve in a race track.

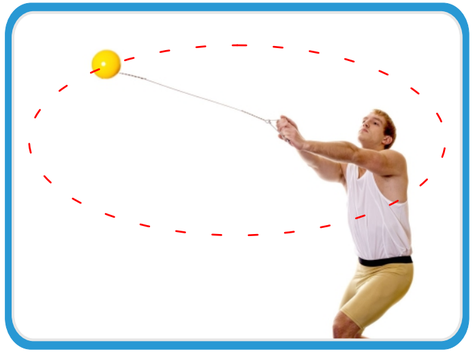


Centripetal and Centrifugal Force

Any object moving in a circle experiences a **centripetal force**. This force is pushing or pulling the object towards the centre of the circle, the point about which it is rotating. Another force that is important in circular motion is the **centrifugal force**, which acts in a direction contrary to centripetal force and it causes the body to be driven away from the centre of the circle. It is labelled as "pseudo force", because it is only an artefact of inertia (the property of objects to resist any change in their motion). The centrifugal force is equal in magnitude and in opposite direction to the centripetal force when the object is in circular path.

Newton's 2nd law of motion

Newton's Second Law states that **the sum of forces acting on an object is equal to the mass of the object multiplied by its acceleration** (increase or decrease in speed) **of the object.** If a boby is in circular motion the net force is equal to the **centripetal force**. Force, mass and acceleration are interrelated! We could state the relationship in two ways: (a) for the same mass, the bigger the force the bigger the acceleration and (b) to achieve the same acceleration, the bigger the mass the more force is needed.



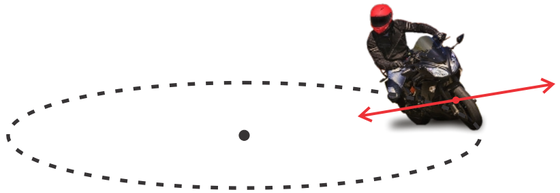
Velocity and Circular Acceleration

In order to understand what acceleration is, we need to understand the notion of velocity first. **Velocity** is the change in distance over time, it shows how fast or slow an object is moving. The velocity of an object in circular motion is continuously changing, since the direction is changing. **Acceleration is the change in velocity of an object**, from slow to fast or from fast to slow. **Circular acceleration** is defined as the rotation about a point following a circular path or a circular orbit. Whatever the object, if it moves in a circular path, there is some force acting on it causing it to change from its straight-line path, accelerate inwards and move along a circular path.

Quiz

Exercise

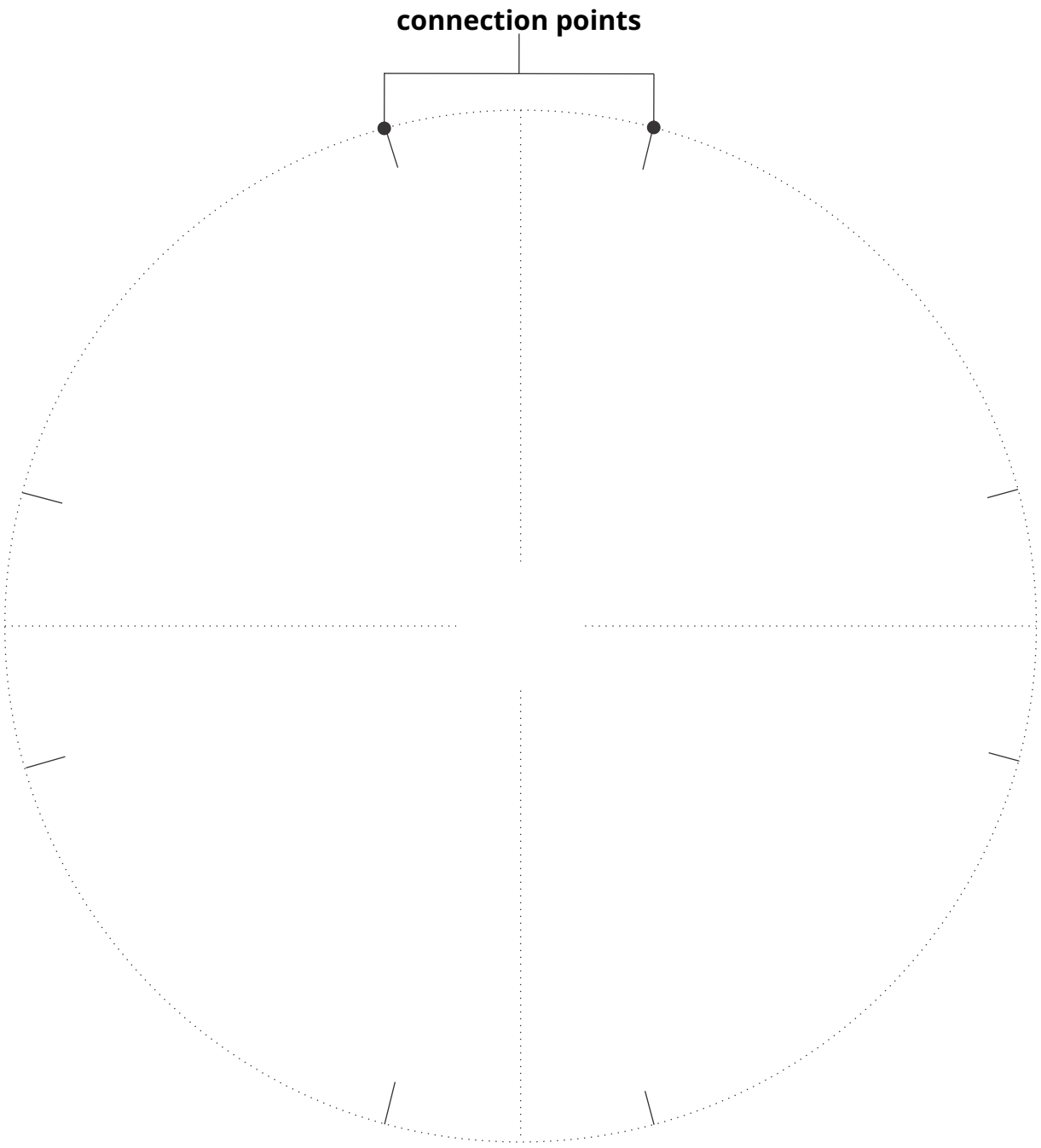
a) The motorcycle below is in circular motion. Draw the direction of the centripetal and of the centrifugal force?



b) It is given that the centripetal force acting on the motorcycle has a magnitude of 100N while the centrifugal force has a magnitude of 120N. Explain whether the motorcycle will derail or not.

It is obvious that the centrifugal force is greater than the centripetal force. For that reason the motorcycle will derail and escape from the circular orbit.

Knowledge check: check what you have learned.

- [ ] What is circular motion?
- [ ] What is the relationship between centripetal and centrifugal force?
- [ ] What does Newton's 2nd law state?
- [ ] Is velocity constant in circular motion?
- [ ] What is circular acceleration?

a) Print this page on an A4 paper.
b) Use the scissors to cut along the **dotted** line.
b) Join the adjacent connecting points and strap them using the stabler or glue.